ISFSI

INSTRUCT-O-GRAM

THE HANDS-ON TRAINING GUIDE FOR THE FIRE INSTRUCTOR

VOLUME XXIV • ISSUE 3 MARCH 2003

Thermal Imaging Cameras

TASK

This training program has been created to prepare you to use a thermal imager in an ever-changing, extremely dangerous and highly stressful environment. Only your commitment to continued and ongoing training with your thermal imager will allow you to increase the safety and effective use of it in an actual life safety situation.

OBJECTIVES

1. Upon completion of this course the student will be able to define what thermal imaging is.
2. Upon completion of this course the student will be able to demonstrate proper exterior size-up techniques using the thermal imaging camera.
3. Upon completion of this course the student will be able to demonstrate proper interior size-up techniques using the thermal imaging camera.
4. Upon completion of this course the student will be able to demonstrate proper safety techniques using the thermal imaging camera.

INSTRUCTIONAL AIDS

Instructional aids will vary with each particular drill. Utilize the equipment that you have available on your department's apparatus. New technology can be introduced by utilizing resources at hand.

ESTIMATED TEACHING TIME

Basic Thermal Imaging Camera (TIC) Concepts	.5 hours
Basic Use of Thermal Imaging Camera	1 hour per person
Drills utilizing TIC in cold/nontoxic smoke	1-2 hours per person
Drills utilizing TIC in live fire evolutions	1-2 hours per person

MOTIVATING THE STUDENT

The environments that we enter during emergency operations at best are dangerous and unpredictable. The use of additional tools will enable the firefighter to better accomplish tasks to meet the goals set for the incident scene. These tasks are the strategies and tactics set forth by the Incident Commander that are designed to mitigate the scene and render it safe.

Being competent with every tool and having a working knowledge of the modern technology that is provided in today's fire service will help enhance our mission.

PRESENTATION

I. **History**

A. IR first detected in 1800 by Sir William Herschel - a British Astronomer.

B. The first IR sensor was patented around 1895 for use on steam locomotives.

C. The sensor was a "Bolometer" and the purpose was to warn the engineer about animals or people on the track.

D. World War I had handheld IR sensors to detect humans at 1000 feet.

E. World War II had the first thermal imagers and IR communication devices.

F. Korean conflict provided proof of principle for heat seeking missiles.

G. Vietnam conflict brought modern IR and night vision to the battlefield.

H. Iraqi conflict was the first full integration of IR into virtually all tactical aspects of battle.

I. Basic Information

- Thermal imaging equipment comes in many forms. Several manufacturers currently make helmet mounted cameras, and handheld cameras of all sizes, shapes and weights. All cameras should be tested by the individual to see what will suit their particular application.
- What is shown as white is heat source
- What is shown as dark is cooler.
- *Thermal Inversion*
  - A person in a room is 98.6 degrees. When room temperature is greater than 98.6 the person will appear gray or black, other objects will appear white

II. How Does Thermal Imagining Work?

A. Thermal Imagers work similar to a video camera, except that they detect "infrared energy" (heat) instead of "light" to create an image

B. All objects above absolute zero (-459.7 °F) emit infrared energy according to known laws of Physics.

C. Infrared energy passes through the imager's optics.

D. The energy is focused on the imager's sensor. The sensor converts infrared energy into an electronic signal.

E. IR cameras work very similar to a radio.

F. A radio senses electromagnetic energy at one frequency and shifts it to another – our audible hearing range.

G. An IR camera senses heat energy at one wavelength and shifts it to the visible wavelengths where we can see it.

H. The thermal image is a pictorial representation created by thousands of dots of varying intensity that are proportional to the temperature at an object's surface.

I. Thermal Imaging isn't ***Night Vision.***

Night Vision - is a type of light amplification or intensification, and is not thermal imaging. Night vision requires some small amount of visible light or reflected energy to create an image. "Near IR" is very short wavelength energy – 0.8 to 1.2 microns. Many black & white CCD camera chips can detect Near IR.

J. Infrared wavelengths (in the 8-12 micron range) are not scattered by smoke particulate.

K. Visible light wavelengths are about the same size as the carbon particles that make up the smoke particulate, causing scatter and therefore impairing your vision.

L. ***Vision Thru Smoke***

Longer wavelengths such as radio waves are the least affected by scatter. You will see combustion products, burning particles and other very small hot objects floating in a burning room. This is normal.

III. Methods of Heat Transfer

A. Heat is thermal energy moving from one place to another, always from higher temperature to lower temperature.

B. There are three modes of heat transfer:

- Conduction
- Convection
- Radiation
  - Radiant energy can be emitted (function of the temperature of the surface), reflected off a surface or transmitted through a surface.
  - Materials that are shiny in visible light are probably also good reflectors - in IR.
  - IR energy can transmit through some materials - optical crystals, most plastics. IR energy does not transmit through water, walls or glass.

IV. Thermal Layering or Stratification

A. This is the tendency of gases to form into layers according to temperature.

B. Hottest gases on top, coolest ones on the bottom.

C. If there are sufficient smoke particles in the gases, you may be able to see this with the thermal imager.

D. Most flames are transparent to IR radiation at the long wavelengths the thermal imager operates. What you normally see in IR are the heat products of combustion - smoke and material particles.

E. Flames will appear slightly smaller in infrared than they will visually.

F. Avoid looking at the flames for long periods of time and never look at anything beyond 1500 °F.

V. Limitations of Thermal Imagining

A. All thermal imagers have limitations:

- They can not see through water, glass or any reflective surface as the IR image is reflected, much like an image in a mirror.
- Water, in the form of rain, fog, mist, snow or steam may affect the ability to thermally image a scene.
- Extreme temperatures consistent throughout the room may cause camera white out. This is where the image in the camera is white due to no gradient differences in the objects in the room.
- Failure to charge the battery will result in you getting no image!

B. Thermal imager's range of viewing, like all cameras, imagers and your eyes, is also limited.

C. The effective range of most thermal imagers to recognize a human is about 200 feet.

D. The minimum focus is 3 feet.

E. Depth perception is a concern for personnel. The camera's minimum focus is 3 feet. This will limit you as you maneuver in smoke-filled environments. Failure to utilize standard practices such as feeling in front of you or sounding the floor could result in falls or other injuries.

VI. Thermal Imagining Applications and Uses

A. Size-Up

1. Exterior Size-up
   - The use of thermal imagers in size-up can be extremely helpful in locating the potential seat of the fire.
   - It can also show fire behavior inside the structure by indicating the areas that are the hottest.
   - Can help you determine location of fire when only heavy smoke is showing. This is accomplished by utilizing the areas of high heat to be areas involved in fire.
2. Interior Size-up
   - The six-sided view technique
   - **Floor** – Scan the floor looking not only for victims but for indications of heat and potential hazards such as holes, objects or steps.
   - **Floor to Ceiling** – Scan from the floor to the ceiling slowly. Doing this will allow you to identify the thermal layering or stratification. This layer is important to note. As temperature begins to rise the smoke will bank down towards the floor. With a thermal imaging camera you can see the line of thermal stratification and the changes you can note.
   - **Four sides.** Look at all four walls or sides. This will indicate potential emergency exits like windows should you be required to get out in a hurry. It will also indicate if ventilation is occurring by the pull of heat towards a window or to a different area of the structure due to thermal stratification being visible on the walls. It also allows you to see other personnel working in the room.
   - Last is that you are able to closely examine the room to see if there are any victims.

B. Search and Rescue

- The Thermal Imaging Camera (TIC) gives us a sense that we have not always had full capabilities of during the past. That sense is sight. The infrared images allow us to search faster and more thoroughly than in the past. The images visualized through the camera can help us locate victims and therefore expedite the operation.
- Always look closely at furniture and the floors for body heat traces. These traces indicate someone's presence prior to your arrival.
- On beds examine the bed clothing closely as you search. Often a body will transfer heat through existing bed clothing or linen.

C. Missing Persons or Body Parts

- Usually the only two sources of heat in fields on land searches are the victims and wildlife.
- If a heat source is detected move towards the source
- Bodies much below 6 inches will usually not be seen due to the temperature differences and the clothing of individuals.

D. Ventilation
- Looking at the structure the same way as described for interior operations will work effectively for external operations.
- This technique will show you the need for vertical ventilation of midline.

E. Fire Suppression
- Interior leaders can find the fires that are oftentimes called the needles in the haystack. These fires are hard to find and usually small. TIC will assist you in moving through what could be heavy smoke to find the fire with this infrared technology.
- Exterior structural examinations help you find the bulk of the fire and allow officers to make conscious decisions whether it is simple or a complex operation is needed.
- Interior crews can now apply water more efficiently to the fire without normal vision. This minimizes water damage as we can focus streams directly to high volumes of fire.
- Officers can now direct crews and have a stronger grip on accountability.

F. Overhaul
- Now hidden hot spots can be found without creating heavy damage. Just focus on the ceiling and find the hot spots. Then you can pull down a minimum or cut open a small area rather than having to gain access to larger areas to ensure the fire is out.

G. HAZMAT
- Many chemical reactions occur when chemicals are released from their original containers. Utilizing infrared TICs we can see exothermic and endothermic reactions from the chemical reacting with the environment or other chemicals. This will help us locate the product and help isolate it from further contamination, run off or identify if multiple chemicals are involved.
- Containers of liquid can be assessed by utilizing TICs. The portion of the tank that is loaded with liquid will indicate a line of stratification. This is useful in determining the amount of a product loss or what is potentially going to be lost.
- In Offensive operations on hazardous materials incidents this will afford another luxury with a tool to determine if there was any leak by seeing the chemicals exothermic or endothermic reaction with the atmosphere and the surrounding environment.

RESOURCES

North Carolina Fire and Rescue Commission Thermal Imaging Instructor Upgrade, North Carolina Department of Insurance, The Office of the Fire Marshal

Chapel Hill Fire Department Training Standard, Chapel Hill Fire Department, Chapel Hill, North Carolina, 1998

Massachusetts Firefighting Academy, Thermal Imaging Training, Marlborough, Massachusetts

Bullard Thermal Imaging Camera Training Program

ACKNOWLEDGMENT

The materials in this *Instruct-O-Gram* were prepared by Douglas K. Cline, BSW, NREMT-P, Captain, Chapel Hill Fire Department, Chapel Hill, North Carolina, and ISFSI Eastern Regional Director.